OBSERVATIONS ON BEHAVIOR IN SCARITES (COLEOPTERA: CARABIDAE: SCARITINI)

By Thomas F. Hlavac[1,2]

Introduction

The genus *Scarites* Fabricius contains a large number of species of large, fossorial, pedunculate beetles and is found in all geographic regions, except the Australian. The number of species in America, north of Mexico, is open to question. Banninger (1938) recognizes 1 species and 7 subspecies while Ball (1960) states that 2 or 3 species may be present but concludes that this group "requires thorough study to determine the number of species present." For the northeastern United States 2 species have been recognized which differ mainly in size (Blatchley *1910): subterraneus* Fabricius 15 to 20 mm. long; and *substriatus* Haldemann, 25 to 30 mm. These forms are sympatric over much of their range with *subterraneus* reaching southern Canada (Lindroth 1961). Habitat differences, if any, are not known. Since these forms are sympatric with no apparent intergradation, they fulfill the definition of a biological species (Mayr, 1963, pp. 19-20) and should be regarded as specifically distinct.

The biology of the genus *Scarites* is poorly known. It is hoped that these observations will shed some light on the behavior and ecological morphology of this genus of carabid beetles.

Burrowing Behavior

The burrowing behavior of captive adult *Scarites subterraneus* Fab. and *substriatus* Hald. (Scaritini, Scaritina) was studied by placing adults on a damp sand substrate 5 inches deep in 21 x 7 x 6 inch plastic containers. The beginning of the burrow is invariably made against the side of the container, frequently in a corner. The mandibles are employed to loosen the substrate which is pushed to the side by the pro- and mesotibia. The head and pronotum are raised at intervals to pack loose material to the ceiling of the burrow. After substrate approximately equal to one body length has been loosened, the burrow is enlarged by an upward thrusting of the head and pronotum. If the substrate is not deep, the burrowing may be heard; a series of scraping scratching sounds, the work of the mandibles and protibia, followed by a dull crunching sound, the up-heaving. Of fifty burrow beginnings which I have observed, all but one followed the above pattern. In the sole exception the beetle began the entrance normally, but when the burrow was about one head length long, it began carting clumps of sand to the surface in the mandibles and depositing them on the surface around the entrance hole. As the burrow was lengthened, the loosened material was passed to the meta-legs and backed out to the surface. Frequently the beetle backed a load of sand out of the burrow, exited, and pushed aside the material accumulated at the burrow entrance. In five subsequent burrow beginnings this individual began in the normal manner, not bringing sand to the surface with the mandibles and metalegs.

The burrow is usually continued around the outer edge of the container next to the bottom. A few exit holes are made at this time. The burrow system is

---

[1]Department of Entomology, Michigan State University, East Lansing.

[2]I wish to gratefully acknowledge the help of Drs. Roland L. Fischer and William L. Downes for reading and criticizing the manuscript, Richard J. Snider for numerous helpful suggestions, and my wife, Barbara C. Hlavac, for preparing the illustrations.

enlarged by constructing branches toward the center of the container and numerous exit holes off the perimetal burrow. From the surface, the fully developed perimetal burrow appears as a large number of evenly spaced exit holes approximately one body length apart. No generalizations can be made about the pattern of internal burrow systems.

Both species of *Scarites* apparently spend the daylight hours motionless in the burrow. Specimens were repeatedly observed on the surface during the night. As soon as a light is turned on the beetle scurried about and entered a burrow. Food getting is one function of these nightly wanderings. In the few instances where prey-capture has been observed on the surface, the food item was seized by the mandibles; the beetle then began to back up in an apparently random manner until it backed into the first exit hole encountered. Feeding has never been observed on the surface. A specimen of *S. subterraneus* was once observed just inside the exit hole; it was offered a living dealated house fly placed 2 cm. in front of the beetle. As the fly began to beat about on its wing stubs, the beetle emerged, seized the fly and quickly backed into the burrow. Food placed in the burrow system was also eaten. In nature, these beetles burrow in mud and moist soil which is rich in soft-bodied insect larvae and annelids. It is possible that under these conditions most of the prey could be obtained from the burrow system. Because of the narrowness of the burrow, mating must take place on the surface.

Unlike most Carabids, death feigning is practiced in both *S. subterraneus* and *substriatus*. When handled roughly the beetle tucks in the legs and antennae, and rotates the pronotum upwards. The only motion made by the death feigning beetle is a slight twitching of the palpi. This comatose condition is maintained for very variable periods, sometimes up to 5 minutes. Specimens collected under logs and boards are almost always found in this state.

Intraspecific aggression, not common in carabids, is particularly well developed in these scaritines. Two specimens of any sex combination placed together begin almost invariably, upon contact, to bite each other on any part of the body with the mandibles. When a mandible is seized the attacker attempts to flip the other beetle on its dorsum with quick lateral jerks of the head and pronotum. This is normally countered by the "attacked" *Scarites* with a thrust of the pronotum and head in the opposite direction. If both beetles should exert a force in the same direction they tumble over and for an instant form an inverted V, the apex of this V being the united heads of the beetles and the basal point the elytral apices. No injuries have been inflicted in these combats, but several specimens which had been kept overnight in a large jar were dead and eaten out, the remaining live ones were lacking antennal segments and tarsi. All specimens were alive and complete when collected. In nature, this intraspecific aggressive behavior would tend to limit population density, and may indicate territorality.

Mating Activity

Four complete and several inconclusive matings of a single captive pair of *S. substriatus* collected in Saginaw and Wayne Counties, Michigan, were observed between June 1 and 15, 1965. These beetles were placed on damp sand substrate as previously described. Both immediately began to run about the surface staying near the perimeter much of the time. Upon meeting, the ♂ grasped the ♀ in its mandibles; the site of the preliminary bites depending upon the angle of

interception. The ♀ reacted to this "attack" either by running off, with the ♂ following, or by turning about and facing the ♂ and biting his head and pronotum. In this head to head position, the ♂ quickly seized a mandible of the ♀, grasped it tightly and using it as a point of rotation, he swung about and mounted the ♀. The antennae of both beetles vibrated in a large arc while facing each other and while the mandibles were interlocked until mounting. Courtship behavior differs little from simple agressive behavior, between members of the same sex as described above. Mounting is quickly followed by intromission after which the ♂ released his hold on the ♀'s mandible and grasped her head just anterior to the eyes on the posterior lateral portion of the frontal plate. The beetles were, for the most part, motionless during copulation. Occasionally, however, the ♀ began to walk about, at which point the ♂'s hind legs which had been hanging free and not touching the ♀ began to "run" rapidly, lightly brushing the elytra and abdominal sternites of the ♀ who quickly ceased walking. Mating was terminated by the male withdrawing the aedeagus, releasing the ♀'s head and sliding off. On one occasion the ♂ approached the ♀ from behind. After biting the apex of her elytra once, he quickly mounted, grasped the ♀ in front of the eyes, and inserted the aedeagus. Matings, beginning at interception, lasted 5, 6, 7 and 8 minutes.

Alexander (1959) observed the mating of *Pasimachus punctulatus* Haldemann (Scaritini, Pasimachina) on July 9 in Hocking Co., Ohio, under natural conditions. Members of this subtribe do not burrow as do the Scaritina but run swiftly on the surface in search of prey.

The major differences between the mating behavior of *Scarites* and *Pasimachus* are found in the behavior of the ♂. The mandibles of ♂ *P. punctulatus* are considerably longer than the ♀'s. During courtship and copulation, these are used to grasp the female around the peduncle (the narrow anterior portion of the mesothorax). Alexander reports that prior to intromission the ♂ taps the ♀'s apical edge of the terminal abdominal sternite with his parameres for a period of 90 seconds. This paramere tapping has not been observed in *Scarites*.

The posterior lateral portion of the frontal plate in *Scarites* differs considerably from that of *Pasimachus*. These structural differences are correlated with mating behavior. In *Scarites* this surface is flattened, slopes medially, and has a groove along the ventral margin and a definite dorsal ridge (fig. 1). In *Pasimachus* neither a dorsal ridge nor a ventral groove is present (fig. 2) and the surface curves gently, most of the surface area being in a vertical plane.

Larval Activity

Second and third instar larvae of *S. subterraneus* were observed in the laboratory under conditions similar to those described for adults. Five larvae were obtained from ♀'s in a manner which may give an insight into behavior under natural conditions. Three ♀'s collected June 18, 1965 in Barry County, Michigan, were confined in separate containers in a moist sand substrate. On July 1 the beetles were removed and plaster of Paris poured into the burrow system to obtain a cast. The next day a larva was observed against the side of the container in a burrow of its construction. In the next two days, 4 additional larvae were collected in the same manner. Three larvae were collected from 1 container and 1 each from 2 others. The sand employed was collected from a lake beach several months before in a very dry form and had been stored dry until moistened for use. It would seem reasonable to suppose that these larvae were the offspring of the captive ♀'s and that no macroscopic food was available to the larvae in

the substrate. Each adult had been fed twice in the 13 days since capture; the food in both cases was dragged into the burrow system. A detailed search of the plaster cast failed to reveal any larval burrowings emanating from the adult burrows. These larvae presumably fed on insect pieces brought into the burrow by the adult. There would seem to be a possible relationship between the parent and larvae. It would be hasty, however, to make any definite statement on the basis of these few observations.

Larval burrows run parallel to the surface, then slope upward for a short distance and lead to a 45° angle opening at the surface. This latter portion is about equal to one body length of the larva. Specimens were frequently observed, in dim light, in the burrow with the long, slender mandibles extending above the surface. As a piece of dead insect was brushed against the mandible, the larvae rapidly seized it and dragged it below the surface and began to feed. If the item was too bulky to be brought into the burrow, the larva pulled as much in to the burrow as possible and fed on it from below. The larvae, like the adults, leave the burrow at night and wander about the surface of the substrate.

The second molt took place on July 7 in an enlarged bottom edge burrow. Fully colored adults left the pupal chamber in a corner of the container between August 18 and August 20.

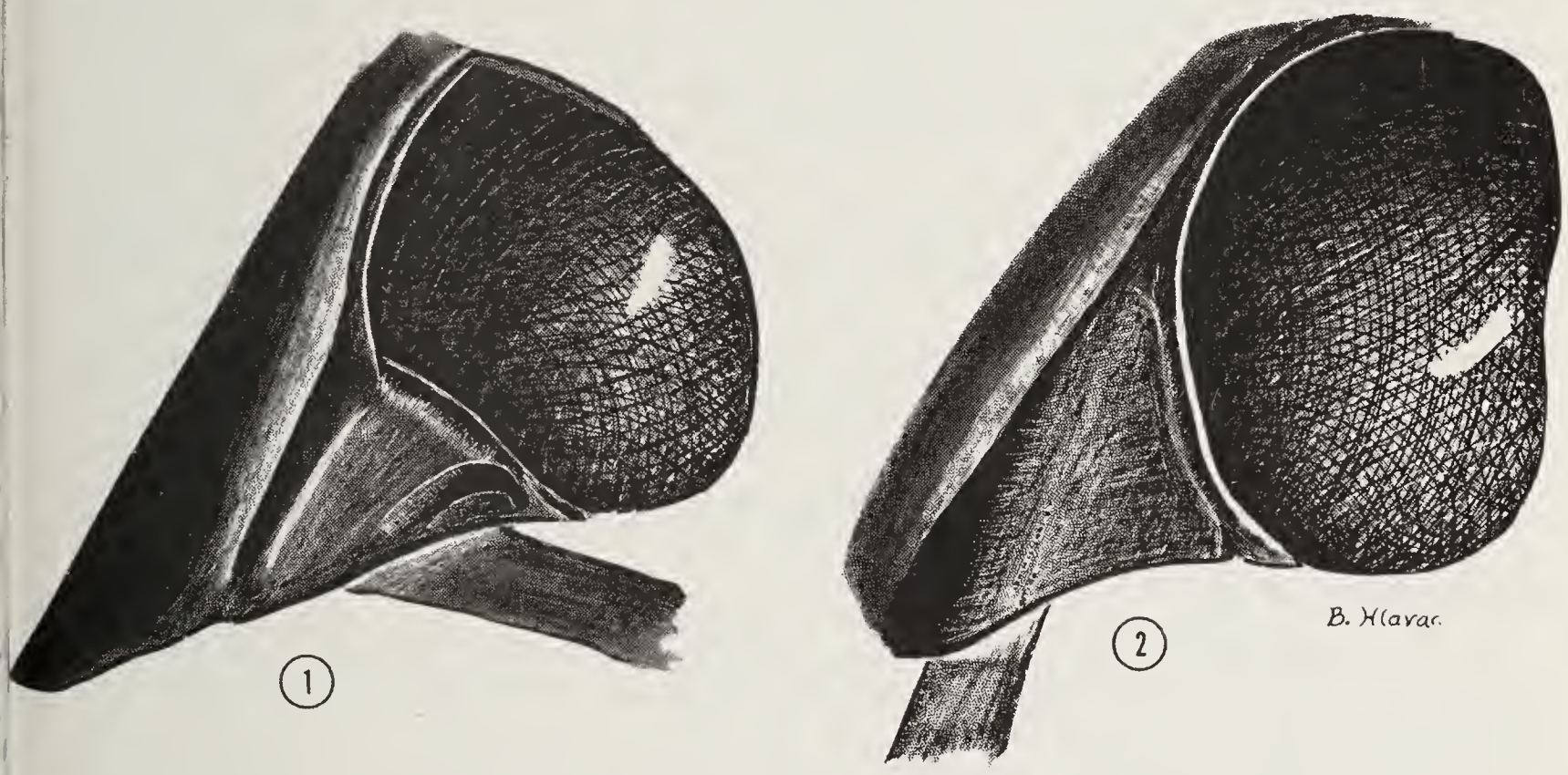

FIGURE 1 Lateral view of frontal plate of *Scarites subterraneus* Fab.
FIGURE 2 Same of *Pasimachus punctulatus* Hald.

DISCUSSION

Several morphological features of *Scarites* seem to be adaptations for a fossorial existence. The mandibles of scaritine carabids are typically large and conspicuous, are employed in "eating away" the head area of the burrow, in mating, and in seizing and chewing prey. The distal portion is slender, sharp and is used in seizing prey and burrowing. The proximal or molar area is employed in crushing and squeezing tissues out of the exoskeleton of insect prey (carabids rarely ingest large solid food particles). The amount of wear on the mandibles and on the body surface is considerable. The ratio: length of mandible/interocu-

lar distance, varied from .8 in teneral examples of *S. subterraneus* to .6 in well-worn, overwintered forms. The lateral portion of the vertex is modified in most scaritines to form a round plate covering the antennal insertion, protecting it from mechanical injury. The antennal scape is long and while burrowing is held at a right angle to the flagellum. This position is employed when the beetle is patrolling the burrow system and when seizing prey on the surface. When on the surface, the scape and flagellum are held in alignment and pointed forward at about a 45° angle to the long axis.

The broad digitate protibia and the strong setae on the lateral margin of the meso- and metatibia are employed in clearing the burrow of material loosened by mandibles and pronotum. The larvae also burrow with the legs and mandibles. The pro-legs are morphologically similar to the meso- and meta-legs. All 3 pairs have the trochanter femur, and tibia armed on the ventral surface with a large number of short, stout spines.

The pedunculate body form is found in many diverse taxa of burrowing insecta, i.e., Passalidae, Lucanidae *in partem* and Gryllotalpidae. A narrow pro-meso thorax articulation allows the pronotum to rotate through a wide angle dorsoventrally, which in *S. substriatus* is about 45°. While burrowing, the head and pronotum are frequently rotated upward and the head positioned so that the flat vertex is roughly parallel with the surface. Dorsoventral scraping of the head of the burrow with the mandibles is accomplished more through rotation of the prothorax than through the rotation of the head.

Literature Cited

Alexander, R. D.

1959. The courtship and copulation of *Pasimachus punctulatus* Haldemann (Coleoptera:Carabidae). Ann. Ent. Soc. Amer. 52: 485

Ball, G. E.

1960. *In* R. H. Arnett, Jr. The Beetles of the United States. The Catholic University of America Press, Washington, D. C. fasc. 4: 55-181

Banninger, M.

1938. Monographie der subtribus Scaritina (Col. Carab) II Deutsche Ent. Zeit. (1938), part 1: 41-182

Blatchley, W. S.

1910. An illustrated descriptive catalogue of the coleoptera or beetles known to occur in Indiana, Indianapolis, Indiana. 1385 pp.

Lindroth, C. H.

1961. The ground-beetles (Carabidae excl. Cicindelinae) of Alaska and Canada, Pt. II. Opuscula Entomologica Supplementum XX: 1-200

Mayr, E.

1963. Animal Species and Evolution. Harvard University Press. 797 pp.

While this paper was in press the mating behavior of Pasimachus elongatus was described by D. C. Cress (Journ. Kansas Ent. Soc., 39: 231-232, 1966). The male mounts from behind and grasps the female's peduncle; the pair then rolls over with the male resting on his dorsum. In this position, the apices of their abdomens are brought into line by a jerk of the male's head moving the female posteriorly. The male then releases the peduncle and grasps the female just behind the eyes, intromission follows.